BOND CHARACTERISTICS OF CARBON FIBER REINFORCED POLYMER STRENGTHENED CONCRETE MEMBER EXPOSED TO ACIDIC SOLUTION

Kannan Thushanthan

208103K

Degree of Master of Philosophy

Department of Civil Engineering

University of Moratuwa
Sri Lanka

January 2023

BOND CHARACTERISTICS OF CARBON FIBER REINFORCED POLYMER STRENGTHENED CONCRETE MEMBER EXPOSED TO ACIDIC SOLUTION

Kannan Thushanthan

208103K

Thesis submitted in partial fulfilment of the requirements for the degree

Master of Philosophy in Civil Engineering

Department of Civil Engineering

University of Moratuwa

Sri Lanka

January 2023

DECLARATION

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Also, I hereby grant to University of Moratuwa the non-exclusive right to reproduce and distribute my thesis, in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as articles or books).

Signature: Date: 25/02/2024

The above candidate has carried out research for the Master of Philosophy under my supervision.

Name of the supervisor: Prof. (Mrs) J.C.P.H. Gamage

Signature of supervisor: Date: 28.02.2024

ACKNOWLEDGEMENT

I am grateful to gain this opportunity to express my thanks to the individuals who have so far guided me to successfully complete this research project.

I would like to extend my heartiest gratitude to my supervisor Prof. (Mrs). J.C.P.H. Gamage, Professor, Department of Civil Engineering, University of Moratuwa for her immense trust, support and guideline provided throughout the entire duration to successfully complete this research.

My heartiest graduate to Dr. H. G. H. Damruwan, and Mrs. Anuradha Silva for the valuable advice and comments given in the progress presentation. My sincere thanks to Prof. (Mrs). C. Jayasinghe, Head of Department of Civil Engineering, University of Moratuwa and Prof. S. A. S. Kulathilaka, former head of Department of Civil Engineering, University of Moratuwa**,** for their support and providing necessary facilities in completing this study.

I am obliged to give my special thanks to Building Construction and Materials (BCM) and Structural testing laboratory technicians for providing valuable support for experiment and testing.

Furthermore, my sincere gratitude to the staff of Board of Investors (BOI) Sri Lanka for helping during the case study period. Also, my sincere thanks to the academic and non-academic staff of the Department of Civil Engineering, University of Moratuwa for the guidance and support provided towards this research. I extend my gratitude to all previous researchers, whose contributions, I have made use of in carrying out this research project. Last but not least, I am truly thankful to all my colleagues for the great help extended when carrying out the research project from the beginning to the end.

Kannan Thushanthan

Department of Civil Engineering

University of Moratuwa

ABSTRACT

Deterioration of construction materials due to aggressive environments is becoming a serious issue nowadays. Concrete is a widely used construction materials however, due to its alkaline nature, it is highly susceptible to acidic corrosion. Therefore, the concrete structures lose the aesthetic appearance and become structurally unsafe even before it's intended service life. In order to rehabilitate these deteriorated structures fiber composites were introduced in the civil engineering industry. Several types of fiber composites are available for the civil engineering application, however, due to the superior engineering properties Carbon Fiber composites are commonly used to strengthen buildings which may experience aggressive environments. Carbon Fiber Reinforced Polymer (CFRP) composites consist of carbon fibers which are relatively immune to the aggressive environmental conditions and epoxy resin matrix which is highly susceptible to environmental degradation. Extensive researches were conducted all around the world to investigate structural strengthening and load transfer mechanisms of CFRP strengthened system however, environmental degradation of these systems were studied comprehensively. Especially, very minimum research studies were conducted to investigate the degradation of CFRP to concrete strengthened system in acidic environment.

This study aims to address the lacuna regarding the deterioration behaviour of CFRP to concrete strengthened system in acidic environmental conditions. Extensive literature review was conducted to identify available research studies and limitations in CFRP to concrete strengthened system in aggressive environmental conditions. At the beginning, a case study was conducted at Awissawela wastewater treatment, which was renovated from a near collapse condition by CFRP composite. Later experimental studies were conducted to study the degradation behaviour of CFRP, concrete and CFRP-Concrete interface under various acidic condition. These acidic conditions were simulated in order to achieve actual conditions identified in several locations. Series of accelerated environmental exposure were conducted and several tests were carried out.

Finally, the obtained results were statistically analysed and conclusions were presented.

Key words: *CFRP, Concrete, Acidic Environment, Deterioration, Residual strength, SEM, UPV*

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

Abbreviation	Description
FRP	Fiber Reinforced Polymer
CFRP	Carbon Fiber reinforced polymer
UV	Ultraviolet
MIC	Microbial Induced Corrosion
SEM	Scanning Electron Microscopy
ASTM	American Society for Testing and Materials
UTM	Universal Testing Machine
COV	Coefficient of Variation
SD	Standard Deviation
UPV	Ultrasonic Pulse Velocity
RDME	Relative Dynamic Modulus of Elasticity